

# Overview

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## Overview

### Key Issues

A major issue in energy markets today is carbon emissions. Because the Kyoto Protocol has not been ratified by the United States and no specific policies for carbon reduction have been enacted, such policies are not included in the *Annual Energy Outlook 1999* (AEO99), although the Protocol and EIA's recent analysis of its potential impacts are discussed.

Economic developments in Asia over the past 18 months have weakened worldwide oil demand and lowered world oil prices—a trend that is likely to continue for several years and, therefore, is included in the AEO99 analysis of oil markets and prices.

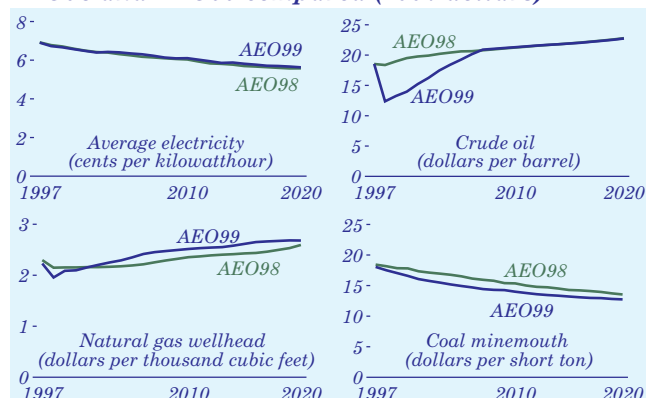
As in AEO98, the projections in AEO99 reflect ongoing changes in the financial structure of the U.S. electricity industry and cost reductions that are becoming evident with increased competition. A transition to retail competitive pricing is assumed in five regions—California, New York, New England, the Mid-Atlantic Area Council (Pennsylvania, Delaware, New Jersey, and Maryland), and the Mid-America Interconnected Network (Illinois and parts of Wisconsin and Missouri). Provisions of the California legislation on stranded cost recovery and price caps are also included. In the other regions, stranded cost recovery is assumed to be phased out by 2008. No national renewable portfolio standard has been passed, but State standards and other programs intended to encourage renewables are included as enacted. The new standards for control of nitrogen oxide (NO<sub>x</sub>) emissions by electricity generators are also incorporated.

### Prices

Although average world crude oil prices in AEO99 are similar to those in AEO98 by 2020, the projected prices over the next several years are much lower (Figure 1). In 2020, the average crude oil price is projected to be \$22.73 a barrel (in 1997 dollars), compared with \$22.78 a barrel in AEO98. With the economic downturn in many Asian nations and lower expected growth in world oil demand, world oil prices are expected to remain low over the next several years—as much as about \$5.50 a barrel lower than last year's projections in 2000.

After the start of the next decade, world oil demand is expected to rebound. Worldwide demand for oil is

**Figure 1. Fuel price projections, 1997-2020: AEO98 and AEO99 compared (1997 dollars)**



projected to reach 114.7 million barrels a day in 2020, only slightly lower than the AEO98 projection of 116.6 million barrels a day.

Through 2020, the relatively low growth of prices even as the demand for oil increases reflects continued optimism about the potential growth of production in both the Organization of Petroleum Exporting Countries (OPEC) and the non-OPEC nations. Although not increasing as rapidly as in AEO98, OPEC oil production is expected to reach 58.8 million barrels a day in 2020, nearly double the 29.9 million barrels a day in 1997, assuming sufficient capital to expand production capacity. Once sanctions are lifted, Iraqi oil production is expected to reach 2.5 million barrels a day within 2 years and about 5 million barrels a day within a decade. Outside the Persian Gulf, expansion of production in the offshore regions of Nigeria and Algeria and in Venezuela should make a significant contribution to OPEC production.

Non-OPEC oil production is expected to increase more rapidly in AEO99, reaching 55.6 million barrels a day in 2020, compared with 50.4 million barrels a day in AEO98. Contributing to the growth are a near doubling of production in the former Soviet Union by 2020 (primarily in the Caspian Sea oil fields), new fields in the North Sea, and increases in the offshore regions of West Africa. Mexican oil production will continue to expand, and the rest of Latin America is projected to increase production by more than 50 percent, particularly in Brazil and Colombia. Lower OPEC production and higher non-OPEC production than in AEO98 mean that OPEC does not dominate the world oil market until later in

the forecast and reaches a market share of only 51 percent, compared with 57 percent in *AEO98*.

The average wellhead price of natural gas is projected to increase from \$2.23 per thousand cubic feet in 1997 to \$2.68 per thousand cubic feet in 2020, an average annual growth rate of 0.8 percent. Continued technological improvements in the exploration and production of natural gas moderate the price increase even as demand grows rapidly. In 2020, the price is higher than the \$2.59 projected in *AEO98*, primarily because of a lower assessment of the recoverable resource base. Average delivered prices decline between 1997 and 2020 as a result of efficiency improvements in transmission and distribution; however, margins are as much as \$0.20 to \$0.30 per thousand cubic feet higher in *AEO99* than in *AEO98* in the 2000 to 2010 period, because recent data indicate fewer pipeline and distribution cost reductions than previously assumed.

In *AEO99*, the average minemouth price of coal is projected to decline from \$18.14 per ton in 1997 to \$12.74 per ton in 2020, as a result of increasing productivity in the industry, more production from lower-cost western mines, and competitive pressures on labor costs. Slightly lower production and higher productivity, as noted in recent data, lead to a price that is lower than the \$13.55 in *AEO98*.

Average electricity prices decline from 6.9 cents per kilowatthour in 1997 to 5.6 cents per kilowatthour in 2020, the same as in *AEO98*. The restructuring of the electricity industry contributes to declining prices throughout the Nation through lower operating and maintenance costs, lower administrative costs, and other cost reductions. Federal Energy Regulatory Commission actions on open access and other regulatory initiatives for competitive markets enacted by some State public utility commissions are included in the projections, as are renewable portfolio standards and other mandates that have been passed in some States. Legislative actions affecting the electricity industry are discussed in the “Legislation and Regulations” section of this report (page 14), and electricity pricing is discussed in “Issues in Focus” (page 24).

### Consumption

Total U.S. energy consumption is projected to increase from 94.0 to 119.9 quadrillion British

thermal units (Btu) between 1997 and 2020, an average annual increase of 1.1 percent. In 2020, consumption is slightly higher than the 118.6 quadrillion Btu projected in *AEO98*, with higher commercial, industrial, and transportation demand partially offset by lower residential demand.

Consumption in the residential and commercial sectors is projected to increase at average rates of 0.8 and 0.7 percent a year, respectively, led by growth for a variety of equipment—telecommunications, computers, and other appliances. Residential demand is lower than in *AEO98*—22.9 quadrillion Btu in 2020, compared with 23.2 quadrillion Btu, because more efficient building shells in new construction offset higher growth in the housing stock. In the commercial sector, data from the *Commercial Buildings Energy Consumption Survey 1995* indicate less floorspace but higher energy intensities for some end uses. Commercial demand is projected to be 18.1 quadrillion Btu in 2020, 0.6 quadrillion Btu higher than in *AEO98*, primarily because of higher demand for natural gas and electricity.

Demand in the industrial sector increases at an average of 0.8 percent a year and is about 0.6 quadrillion Btu higher in 2020 than in *AEO98*. More rapid efficiency improvement in some manufacturing sectors is offset by higher energy intensity indicated by the *Manufacturing Energy Consumption Survey 1994*. Because the economic downturn in Asia affects the market for U.S. exports, manufacturing output and industrial demand are significantly lower than in *AEO98* over the next 10 years, rebounding later in the projections.

Transportation demand grows on average by 1.7 percent a year and is 0.4 quadrillion Btu higher in 2020 than in *AEO98*. The introduction of direct-injection engines and other advanced automotive technologies improves the efficiency of light-duty vehicles, but the improvement is more than offset by higher travel, resulting from higher projected personal income. Recent data indicate higher load factors and efficiency for aircraft, which are offset by more air travel. Freight requirements for both rail and trucks are also higher, primarily because of the higher economic growth projected in *AEO99*.

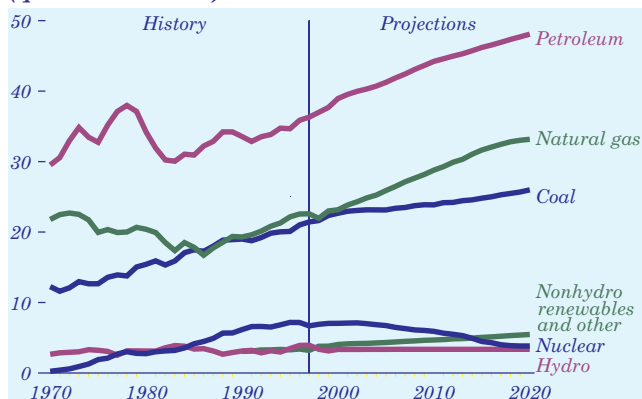
*AEO99*, like earlier *AEOs*, incorporates efficiency standards for new energy-using equipment in

## Overview

buildings and for motors mandated by the National Appliance Energy Conservation Act of 1987 and the Energy Policy Act of 1992. Several alternative cases examine the impact of technology on the projections by assuming more and less rapid improvement of energy-efficient technologies in the end-use sectors relative to that projected in the reference case.

Natural gas consumption increases by an average of 1.7 percent a year (Figure 2). Demand increases in all sectors, but the most rapid growth is for electricity generation, which is projected to increase from 3.3 to 9.2 trillion cubic feet between 1997 to 2020, excluding cogenerators. Total gas consumption is only 0.1 trillion cubic feet higher than in *AEO98* in 2020, with higher demand in the commercial and industrial sectors offset by lower demand in the residential and electricity generation sectors.

**Figure 2. Energy consumption by fuel, 1970-2020 (quadrillion Btu)**



Coal consumption increases from 1,030 to 1,275 million tons between 1997 and 2020, an average annual increase of 0.9 percent. About 90 percent of the coal use is for electricity generation, and coal remains the primary fuel for generation, although its share of generation declines by 2020. Coal demand in 2020 is 18 million tons higher than in *AEO98* because of higher projected demand for electricity generation.

Petroleum demand is projected to grow at an average rate of 1.2 percent a year through 2020, led by continued growth for transportation, which accounts for about 70 percent of petroleum use in 2020. Increases in travel more than offset efficiency increases, and higher economic growth increases freight and shipping, and thus petroleum use, through 2020. Compared with *AEO98*, total transportation energy demand is slightly higher, with

higher projected efficiencies for new automobiles and aircraft more than offset by higher travel and freight requirements.

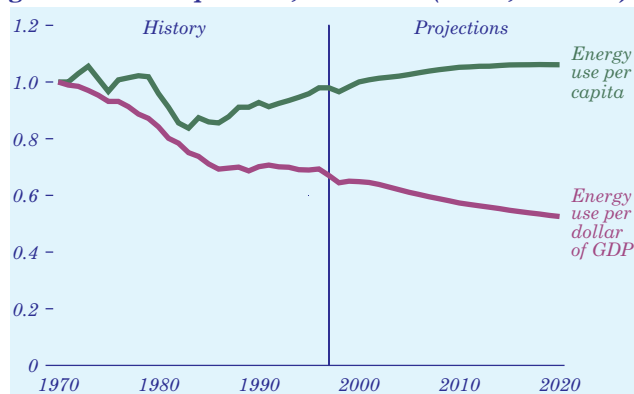
Renewable fuel consumption, including ethanol used for blending in gasoline, increases at an average rate of 0.8 percent a year through 2020. About 60 percent of renewables are used for electricity generation and the rest for dispersed heating and cooling, industrial uses, and fuel blending. In 2020, renewables are 0.7 quadrillion Btu higher than in *AEO98*, with higher demand for electricity generation, industrial uses, and ethanol blending.

Electricity demand is projected to grow by 1.4 percent a year through 2020. Efficiency gains in the use of electricity partially offset the growth of new electricity-using equipment. Electricity demand is only slightly higher than in *AEO98*, because an increase in commercial demand, resulting from more rapid growth of office equipment, computers, and other appliances is offset by a decrease in industrial demand from efficiency improvements in some manufacturing industries.

## Energy Intensity

Energy intensity, measured as energy use per dollar of gross domestic product (GDP), has declined since 1970, particularly when energy prices have risen rapidly (Figure 3). Between 1970 and 1986, energy intensity declined at an average rate of 2.3 percent a year as the economy shifted to less energy-intensive industries and more efficient technologies. With moderate price increases and the growth of more energy-intensive industries, intensity improvements were flat between 1986 and 1996. From 1997

**Figure 3. Energy use per capita and per dollar of gross domestic product, 1970-2020 (index, 1970 = 1)**



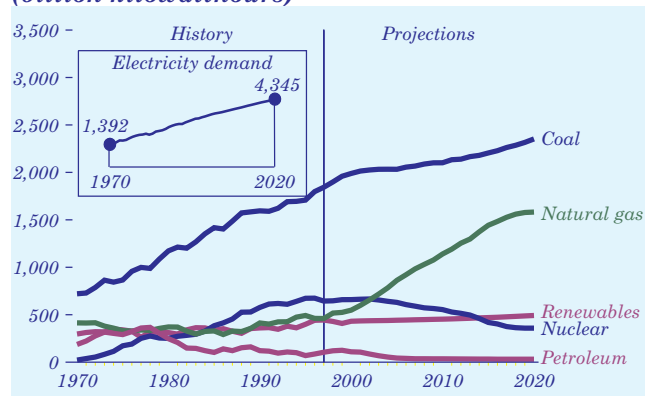
to 2020, intensity is projected to improve at an average rate of 1.0 percent a year as efficiency gains and structural shifts in the economy offset growth in demand for energy services.

Energy use per person also declined from 1970 through the mid-1980s, then increased as energy prices dropped. Per capita energy use is expected to remain stable through 2020 and below the high in the early 1970s, as efficiency gains offset higher demand for energy services.

## Electricity Generation

Electricity generation from nuclear power declines significantly over the projection period (Figure 4). Of the 99 gigawatts of nuclear capacity available in 1997, 50 gigawatts are retired, and no new plants are constructed by 2020. Nuclear plant retirements are based on analyses of operating costs and the costs of life extension compared with the cost of new generating capacity. As a result, some plants are retired before the end of their 40-year operating licenses.

**Figure 4. Electricity generation by fuel, 1970-2020 (billion kilowatthours)**



Generation from both natural gas and coal is projected to increase through 2020 to meet growing demand for electricity and offset the decline in nuclear power. Coal prices are lower than in *AEO98*, leading to slightly higher coal generation, but the share of coal generation declines by 2020 because assumptions about electricity industry restructuring favor the construction of less capital-intensive and more efficient natural gas generation technologies. The natural gas generation share increases from 14 percent to 33 percent between 1997 and 2020. The new NO<sub>x</sub> standards lead to the installation of control technologies at many plants,

with annualized costs of \$2 billion, compared with \$200 billion in annual electricity expenditures.

Renewable generation, including cogenerators, increases by 0.5 percent a year and in 2020 is 11 percent higher than in *AEO98*. Renewable technologies penetrate slowly because of the relatively modest increase in natural gas prices and the decrease in coal prices. In addition, electricity restructuring tends to favor natural gas over coal and baseload renewable technologies. State renewable portfolio standards, where enacted, and other programs to encourage the development of renewable technologies contribute to the growth of renewable generation.

Compared with *AEO98*, lower resource costs in the *AEO99* projections result in more biomass generation, and higher capacity factors for hydroelectric and geothermal facilities lead to higher generation from those technologies. Hydropower, currently the largest renewable resource used for generation, declines slightly through 2020. Its growth is limited by high capital costs, lack of available new sites, reduced Federal investment, and declining public support. Generation from other renewable sources—municipal solid waste, solar, and wind—increases to levels similar to those in *AEO98* in 2020.

## Production and Imports

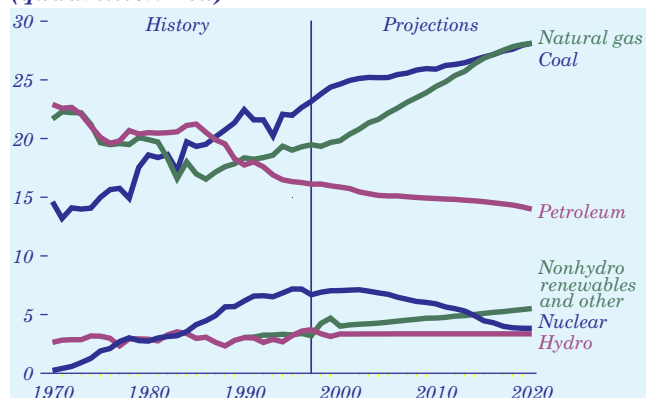
U.S. crude oil production declines at an average rate of 1.1 percent a year between 1997 and 2020 to a projected level of 5.0 million barrels a day. Advances in oil exploration and production technologies do not offset declining resources. Projected oil prices in *AEO99* are similar to those in *AEO98* in 2020, but are significantly lower earlier in the projection period. Higher domestic oil reserves, as indicated by recent data, offset the impact of lower oil prices. Production is similar to or higher than that in *AEO98* through most of the forecast. In 2020, the projected production is essentially the same as in *AEO98*. Total petroleum production (Figure 5) is shored up by production of natural gas plant liquids, which partially offsets the decline in crude oil production.

Declining production and rising demand lead to increasing petroleum imports through 2020 (Figure 6). The share of petroleum consumption met by net imports rises from 49 percent in 1997 to 65 percent however, the share is higher earlier in the projection period because of lower domestic production.

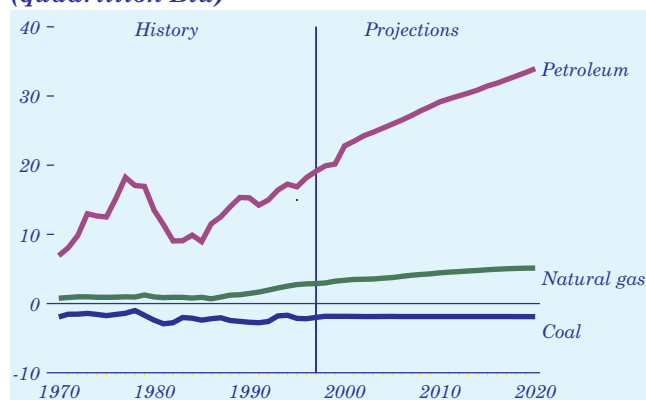


## Overview

**Figure 5. Energy production by fuel, 1970-2020 (quadrillion Btu)**



**Figure 6. Net energy imports by fuel, 1970-2020 (quadrillion Btu)**



In *AEO99*, natural gas production is projected to increase from 18.9 trillion cubic feet in 1997 to 27.4 trillion cubic feet in 2020, an average rate of 1.6 percent a year, to meet most of the rising domestic demand for natural gas. Additional supplies of natural gas are provided by imports. Net imports of natural gas, primarily from Canada, increase from 2.8 to 5.0 trillion cubic feet between 1997 and 2020. It is assumed that pipeline capacity from Canada will increase to accommodate imports of competitively priced Canadian gas.

Coal production grows from 1,099 million tons in 1997 to 1,358 million tons in 2020, an average increase of 0.9 percent a year, to meet rising domestic and export demand. Most steam coal exports serve markets for electricity generation in Europe and Asia. Metallurgical coal exports to Europe and Asia decline. Export demand is lower than in *AEO98* by 35 million tons because of environmental concerns and economic problems in some countries. Because lower export demand is only partially offset

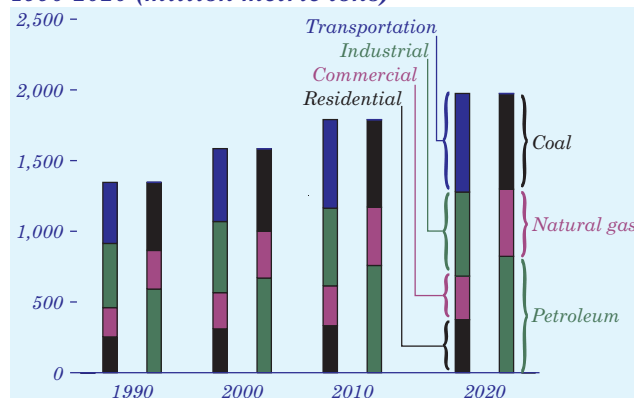
by higher domestic demand, coal production in 2020 is 18 million tons lower than the *AEO98* projection.

Total renewable energy production is projected to increase from 6.8 to 8.2 quadrillion Btu between 1997 and 2020—an average annual increase of 0.8 percent—with growth in electricity generation from geothermal, biomass, and municipal solid waste generation and in industrial biomass and ethanol use. Renewable energy production in 2020 is 0.4 quadrillion Btu higher than in *AEO98*. More renewables are used for electricity generation, cogeneration, and ethanol blending, and *AEO99* incorporates ethanol production from cellulose beginning in 2001, which was not included in *AEO98*.

## Carbon Emissions

Carbon emissions from energy use are projected to increase by an average of 1.3 percent a year through 2020, from 1,480 million metric tons in 1997 to 1,790 million metric tons in 2010 and 1,975 million metric tons in 2020 (Figure 7), due to rising energy demand, declining nuclear power, and slow growth of renewables. Relative to the 1990 level of 1,346 million metric tons, emissions are 33 and 47 percent higher, respectively, in 2010 and 2020. Projected emissions in 2020 are higher by 19 million metric tons than in *AEO98*, due to higher energy demand and higher levels of coal-fired electricity generation.

**Figure 7. U.S. carbon emissions by sector and fuel, 1990-2020 (million metric tons)**



The Climate Change Action Plan (CCAP) was developed to stabilize greenhouse gas emissions in 2000 at 1990 levels. *AEO99* includes CCAP provisions, but no new carbon reduction policies are incorporated. Carbon emissions and the Kyoto Protocol are discussed in "Issues in Focus" (pages 30-41).

Table 1. Summary of results for five cases

Sensitivity Factors	1996	1997	2020				
			Reference	Low Economic Growth	High Economic Growth	Low World Oil Price	High World Oil Price
Primary Production (quadrillion Btu)							
Petroleum . . . . .	16.29	16.23	13.98	13.48	14.47	12.14	15.09
Natural Gas . . . . .	19.32	19.47	28.12	25.63	30.45	27.64	28.24
Coal . . . . .	22.75	23.33	28.12	26.49	29.98	27.65	28.34
Nuclear Power . . . . .	7.20	6.71	3.83	3.65	3.98	3.75	3.92
Renewable Energy . . . . .	6.81	6.82	8.15	7.64	8.79	8.09	8.23
Other . . . . .	1.28	0.66	0.65	0.50	0.79	0.56	0.75
Total Primary Production . . . . .	73.66	73.22	82.85	77.39	88.46	79.83	84.57
Net Imports (quadrillion Btu)							
Petroleum (including SPR) . . . . .	18.25	19.65	33.95	30.53	37.44	38.64	31.20
Natural Gas . . . . .	2.85	2.90	5.14	4.79	5.38	5.01	5.14
Coal/Other (- indicates export) . . . . .	-1.80	-1.65	-1.61	-1.70	-1.51	-1.62	-1.57
Total Net Imports . . . . .	19.28	20.90	37.47	33.62	41.31	42.03	34.77
Discrepancy . . . . .	0.68	-0.08	-0.44	-0.54	-0.40	-0.63	-0.34
Consumption (quadrillion Btu)							
Petroleum Products . . . . .	36.03	36.49	48.08	43.98	52.26	50.69	46.70
Natural Gas . . . . .	22.59	22.59	33.17	30.33	35.74	32.56	33.30
Coal . . . . .	20.60	21.09	26.26	24.48	28.17	25.73	26.43
Nuclear Power . . . . .	7.20	6.71	3.83	3.65	3.98	3.75	3.92
Renewable Energy . . . . .	6.81	6.82	8.17	7.65	8.80	8.10	8.24
Other . . . . .	0.39	0.33	0.39	0.38	0.40	0.40	0.41
Total Consumption . . . . .	93.63	94.04	119.89	110.47	129.36	121.23	119.00
Prices (1997 dollars)							
World Oil Price (dollars per barrel) . . . . .	21.01	18.55	22.73	21.66	23.81	14.57	29.35
Domestic Natural Gas at Wellhead (dollars per thousand cubic feet) . . . . .	2.28	2.23	2.68	2.29	3.09	2.62	2.70
Domestic Coal at Minemouth (dollars per short ton) . . . . .	18.85	18.14	12.74	12.47	12.89	12.66	12.76
Average Electricity Price (cents per kilowatthour) . . . . .	6.9	6.9	5.6	5.1	6.1	5.6	5.6
Economic Indicators							
Real Gross Domestic Product (billion 1992 dollars) . . . . .	6,995	7,270	11,680	10,256	13,106	—	—
(annual change, 1997-2020) . . . . .	—	—	2.1%	1.5%	2.6%	—	—
GDP Implicit Price Deflator (index, 1992=1.00) . . . . .	1.10	1.12	2.13	3.29	1.56	—	—
(annual change, 1997-2020) . . . . .	—	—	2.8%	4.8%	1.5%	—	—
Real Disposable Personal Income (billion 1992 dollars) . . . . .	5,043	5,183	8,905	8,030	9,770	—	—
(annual change, 1997-2020) . . . . .	—	—	2.4%	1.9%	2.8%	—	—
Index of Manufacturing Gross Output (index, 1987=1.00) . . . . .	1.305	1.359	2.137	1.867	2.439	—	—
(annual change, 1997-2020) . . . . .	—	—	2.0%	1.4%	2.6%	—	—
Energy Intensity							
(thousand Btu per 1992 dollar of GDP) . . . . .	13.39	12.94	10.27	10.78	9.88	—	—
(annual change, 1997-2020) . . . . .	—	—	-1.0%	-0.8%	-1.2%	—	—
Carbon Emissions (million metric tons) . . . . .	1,461	1,480	1,975	1,826	2,124	2,006	1,953

Notes: Specific assumptions underlying the alternative cases are defined in the Economic Activity and International Oil Markets sections beginning on page 44. Quantities are derived from historical volumes and assumed thermal conversion factors. Other production includes liquid hydrogen, methanol, supplemental natural gas, and some inputs to refineries. Net imports of petroleum include crude oil, petroleum products, unfinished oils, alcohols, ethers, and blending components. Other net imports include coal coke and electricity. Some refinery inputs appear as petroleum product consumption. Other consumption includes net electricity imports, liquid hydrogen, and methanol.

Sources: Tables A1, A19, A20, B1, B19, B20, C1, and C19.